

## Distribution, frequency and density of the weed *Achillea millefolium* Yarrow in the Snowy Mountains, Australia

Frances Johnston, Wendy Hill and Catherine Marina Pickering

School of Environmental and Applied Sciences, Griffith University, PMB 50,  
Gold Coast Mail Centre, Queensland 9726

### Abstract

This paper examines the distribution of Yarrow *Achillea millefolium* L. (Asteraceae), in the Snowy Mountains. Location data from species specific surveys, field experiments and 18 general vegetation surveys were mapped in relation to altitude/floristic zone, climatic parameters (rainfall and temperature) and location of roads and tracks. *Achillea millefolium* is less common with increasing altitude and benefits from human disturbance. Using all location data, Yarrow was found at 376 sites; nearly all associated with human disturbance (91% of sites) mostly road or trail verges (72%) and around buildings and other ski tourism infrastructure. It occurred along ~100 km of public access roads, management trails and walking tracks, from the tableland to the alpine zone (800 m to 2100 m altitude). The general vegetation surveys, however, indicate that although it can be found in 15% of disturbed sites, it is uncommon in undisturbed vegetation (4%). Yarrow occurred at high density around buildings and low density along walking tracks in the species specific surveys. The distribution of *A. millefolium* demonstrates that human disturbance provides favourable habitats for weeds even in mountains. Although its distribution was affected by altitude, *A. millefolium* was able to establish and grow on some of the highest mountains in Australia, along tracks. Increased disturbances as well as climate change are likely to facilitate its spread. (*The Victorian Naturalist*, 124 (1), 2007, 52-63)

### Introduction

Distribution boundaries of plants are limited by biotic and abiotic factors (Booth *et al.* 2003). Abiotic climatic characteristics such as temperature, precipitation and wind together with light, soil, nutrients, habitat disturbance and species specific characteristics are the major ecological determinants of distribution and abundance of plants (Swincer 1986; Crawley 1987; Cronk and Fuller 1995; Booth *et al.* 2003). As altitude increases, so does the severity of conditions, limiting the species richness of plants including exotics (Körner 2002; Grytnes 2003; Pauchard and Alaback, 2004; Becker *et al.*, 2005; Parks *et al.*, 2005). Plant establishment, growth and reproduction can be limited by decreased temperatures, increased risk of climatic events such as frosts and increased duration of snow cover (Billings and Mooney 1968; Green and Osborne 1994; Körner 1999; Costin *et al.* 2000).

In the Snowy Mountains, Australia, plants in the montane zone (500-1500 m asl) experience intermittent snow cover, and the temperature does not often fall below 0° C (Good 1992). In the subalpine zone (1500-1830 m asl) plants can experience snow cover for one to four months per year

and minimum temperatures below freezing for around six months per year (Brown and Millner 1989; Green and Osborne 1994). In the alpine zone (1830-2228 m) plants experience snow cover for at least four months per year with increased risk of frosts, even in summer (Green and Osborne 1994; Costin *et al.* 2000). As a result of the increasingly difficult conditions many native plant species are unable to establish, grow and reproduce at higher altitude sites. The same seems to apply to exotic taxa, with decreasing richness and abundance of exotics with increasing altitude in the Snowy Mountains (Mallen-Cooper 1990; Johnston and Pickering 2001; Godfree *et al.* 2004; McDougall *et al.* 2005; Bear *et al.*, in press).

Alteration of the habitat by human disturbance can also affect the ability of exotics to establish, with disturbance to native vegetation often favouring exotics (Hobbs 1987, 1989; van der Valk 1992; Lozon and MacIsaac 1997; Booth *et al.* 2003). For example, in the Snowy Mountains there is a strong association between exotics and human disturbance, with most exotics occurring along roadsides and around buildings (Costin 1954; Mallen-Cooper 1990; Johnston and Pickering 2001;

Sanecki *et al.* 2003; Godfree *et al.* 2004; Bear *et al.*, in press).

Of the more than 175 species of exotic vascular plants in the Australian Alps, nine have been identified as of particular concern because of their potential to invade native vegetation. The species considered to be a high threat are *Cytisus scoparius* (Scotch Broom) and the three species of willow, *Salix fragilis*, *S. cinerea* and *S. nigra*. A further five species considered to be a serious threat to the subalpine and alpine floral communities in the Australian Alps are *Rubus discolor* (Blackberry), *Rosa rubiginosa* (Sweet Briar), *Nassella trichotoma* (Serrated Tussock), *Hypericum perforatum* (St. Johns Wort) and *Achillea millefolium* (Coyne 2003).

*Achillea millefolium* is a perennial herb native to Europe and Asia, with its distribution extending from the Mediterranean region to northern Iran to the Arctic Circle (Harden 1990-1993, Zhang *et al.* 1996). It has also been found in the southern hemisphere, including New Zealand and Australia, where it was introduced as fodder, as an ornamental and for its utility in herbal medicines. In temperate New Zealand *A. millefolium* is a major weed in mixed cropping farms, particularly in white clover, peas, beans, beets and other root crops (Bourdôt *et al.* 1979; Bourdôt and Butler 1985; Bourdôt *et al.* 1985; Bourdôt and Field 1988). Although often sold in nurseries in Australia, *A. millefolium* is regarded as an environmental weed in several States (Anon 1998; McDougall and Appleby 2000; Blood 2001) and has been documented as an environmental weed in the Australian Alps (Sainty *et al.* 1998).

*Achillea millefolium* is a weed in many cold, temperate and Mediterranean climates, often in agricultural land (Bourdôt *et al.* 1979; Holm *et al.* 1979; Warwick and Black 1982). It has a long flowering period with large numbers of viable seed produced each season (Bourdôt *et al.* 1979; Warwick and Black 1982; Henkens *et al.* 1992). The rhizome system contains a large number of dormant buds that can produce daughter plants upon rhizome fragmentation (Bourdôt *et al.* 1979; Henkens *et al.* 1992).

Although recorded as early as 1949 in grasslands in the subalpine zone of the Snowy Mountains (NSW Soil Conser-

vation Herbarium database; Costin 1954), populations of *A. millefolium* appear to have increased rapidly during the 1990s (Sanecki *et al.* 2003). The increase is possibly associated with the use of gravel from weed-contaminated dumps in the construction and maintenance of roads and other infrastructure (R. Knutson pers. comm. NSW National Parks and Wildlife Service, 1999). In recent surveys *A. millefolium* was recorded along roadsides and in drainage areas in subalpine zone of the Snowy Mountains with plants present in native vegetation 10 m from the road verge.

This paper assesses the distribution of *A. millefolium* in the Snowy Mountains using data from species surveys and field experiments, and 18 general vegetation surveys. The associations of *A. millefolium* with roads and abiotic factors (altitude, temperature and rainfall) were assessed using geographic information system (GIS) software and the NSW National Parks and Wildlife Service GIS database.

## Methods

### *Location records of Achillea millefolium*

Three sources of location data were used to estimate the distribution of *A. millefolium* within the southern and central sections of the Snowy Mountains. Firstly, specific surveys of *A. millefolium* were conducted along selected roads and around other infrastructure. Secondly, location data were obtained during a series of field experiments examining the phenology of *A. millefolium* (Johnston 2005), resource allocation (Johnston and Pickering 2004) and seed ecology of *A. millefolium* (Johnston 2005) in the Snowy Mountains. These sources are referred to as *A. millefolium* specific records/surveys. Thirdly, location records for *A. millefolium* were selected from a database of records of exotics from 18 general vegetation surveys of 499 sites conducted between 1986 and 2004 in the Snowy Mountains (Bear *et al.* in press).

### *Achillea millefolium* specific surveys/records

Between January and March in 1999 and 2000, sites were surveyed for the presence of *A. millefolium* approximately every two km along the major public access roads (Kosciuszko Road, Alpine Way and the Snowy Mountains Hwy), selected sec-

ondary roads (Guthega Road, Link Road, Island Bend Road and the Summit Road) and selected management trails (Cascade trail, Schlunks Pass Road and Valentine Fire Trail). In addition, disturbed areas around buildings at ski resorts (Smiggin Holes, Perisher Valley and Thredbo Village) and other infrastructure such as huts, toilets and picnic grounds were surveyed for *A. millefolium*.

The precise locations of *A. millefolium* were recorded and an estimate made of site-specific cover/abundance. At infrastructure sites such as solitary huts a single assessment was made of cover/abundance. Cover/abundance was estimated on a six level scale (Low = isolated plants < 5 cm<sup>2</sup> in size, Medium Low = isolated plants > 5 cm<sup>2</sup> in size, Medium = discontinuous cover with distinct gaps between plants, area covered between 5 cm<sup>2</sup> and 30 cm<sup>2</sup>, Medium High = discontinuous cover with distinct gaps between plants, area covered between 30 cm<sup>2</sup> and 50 cm<sup>2</sup>, High = continuous cover, area covered between 50 cm<sup>2</sup> and 70 cm<sup>2</sup>, Very High = continuous cover, areas greater than 70 cm<sup>2</sup> in size.) In these surveys *A. millefolium* was found at 300 sites in the Snowy Mountains.

#### **Location records of *Achillea millefolium* from database of vegetation surveys**

Location records of *A. millefolium* were selected from a database of records of exotic species in The Snowy Mountains, from 18 general vegetation surveys conducted between 1986 and 2004 (Bear *et al.* in press). This database included 1103 records of 154 exotic taxa from 363 sites with exotics. It also included data on 136 sites where exotics were not found in vegetation surveys, giving a total of 499 sites. Sources of vegetation survey data included published research papers, PhD and Honours theses, New South Wales National Parks and Wildlife Service reports and unpublished research by members of the School of Environmental and Applied Sciences, Griffith University (Table 1). Each exotic taxon record had information on its spatial coordinates, vegetation zone, altitude, vegetation community or anthropogenic disturbance type. Sites were considered disturbed if they were highly likely to have experienced vegetation removal and alteration to soils

during construction and use of infrastructure, e.g. sites were defined as disturbed if they were located on the verges of tracks, roads or in the immediate area around buildings, dams etc. Sites were considered natural if they were in areas away from infrastructure and had no other signs of human activity/use.

#### **Mapping the distribution of *Achillea millefolium***

Using the location records of *A. millefolium* from (1) the specific surveys, (2) the experiments and (3) the 18 general surveys, the distribution of *A. millefolium* in Kosciuszko National Park was mapped in relation to altitude/floristic zone (alpine = ~1850 m to 2228 m; subalpine = ~1500 m to ~1850 m and montane = ~1500 to 500 m), climatic parameters (mean annual rainfall and average temperature) and location of roads and tracks using data from the NSW National Parks and Wildlife Service geographic information system (GIS) database and ESRI ArcVIEW GIS software. The locations of 319 sites from the 18 general vegetation surveys where there were exotics other than *A. millefolium* were also mapped to indicate the geographic range of exotics in Kosciuszko National Park. The locations of the 136 sites in the 18 general vegetation surveys where there were no exotics were also mapped.

#### **Results**

From the *A. millefolium* specific surveys, field experiments and general vegetation surveys there was a total of 376 sites with *A. millefolium* in the southern and central sections of the Snowy Mountains (Table 2). There were an additional 323 sites that contained exotics other than *A. millefolium* and 136 sites where only native taxa were found.

#### **Altitude and climate**

*Achillea millefolium* was recorded in tableland, montane, subalpine and alpine zones (800 m – 2100 m) with 85% of sites in subalpine and montane areas (Fig. 1). The climate of these zones is consistent with areas of Australia that have been mapped as suitable habitat for *A. millefolium* (Johnston 2005). Based on the GIS maps of climatic variables the mean annual temperatures of most *A. millefolium* sites were relatively cool, ranging from 3° C to 9° C. Rainfall/



**Table 1.** Details of 18 general vegetation surveys conducted between 1986 and 2004 in montane to alpine zones of Kosciuszko National Park, Australia.

Data source	Floristic zone, vegetation type and disturbance type
Hill W and Pickering CM. Effect of drought and fire on alpine and subalpine vegetation in Kosciuszko National Park: severity of initial impact & predictions for recovery. Unpublished data.	1. Alpine & subalpine zone 2. Natural tall alpine herbfield, windswept feldmark, heath and subalpine grassland burnt in 2003 bushfires and nearby natural unburnt vegetation.
Pickering CM, Growcock A, Hill W, Banks J and Field J Long Plain, Kosciuszko National Park disturbed through prior grazing. Unpublished data	1. Montane zone 2. Woodland and grassland disturbed by livestock grazing practices (>40 years previously)
Pickering CM, Growcock A, Hill W, Banks J, Field J Long Plain Kosciuszko National Park. Unpublished data.	1. Montane zone 2. Natural woodland and grassland
Pickering C, Appleby M, Good R, Hill W, McDougall K, Wimbush D and Woods D (2002) Plant diversity in subalpine and alpine vegetation recorded in the Kosciuszko Biodiversity Blitz. In: <i>Biodiversity in the Mountains</i> . (ed. K Green). Australian Institute of Alpine Studies, Canberra. <sup>1</sup>	1. Alpine and subalpine zone 2. Natural tall alpine herbfield, heath, subalpine grassland and sub-alpine woodland. Disturbed areas in and around ski resorts including ski slopes.
Pickering CM, Growcock A, Hill W, Banks J and Field J Long Plain Transgrid Power lines. Unpublished data. <sup>1</sup>	1. Montane zone 2. Disturbed heath and grassland under powerlines
Hill W and Pickering CM (2006) Vegetation associated with different walking track types in the Kosciuszko alpine area, Australia. <i>Journal of Environmental Management</i> . <b>78</b> , 24-34. <sup>1</sup>	1. Alpine zone 2. Disturbed vegetation on verges of walking tracks and adjacent natural tall alpine herbfield.
Mallen-Cooper J (1990) Exotic plants in the high altitude environments of Kosciuszko National Park, southeastern Australia. PhD thesis, Department of Biogeography and Geomorphology, Research School of Pacific Studies, Australian National University, Canberra. <sup>1</sup> Global Research Initiative in Alpine Environments GLORIA (2004 sampling). Unpublished data.	1. Alpine, subalpine, montane and tableland zones 2. Disturbed road verge vegetation and nearby natural vegetation
Bear Z and Pickering CM (2006). Recovery of subalpine grassland from bushfire: comparison of vegetation in burnt and unburnt paired plots one year post fire in the Kosciuszko National Park. <i>Australian Journal of Botany</i> . <b>54</b> , 451-458.	1. Alpine zone 2. Natural tall alpine herbfield and heath.
Campbell M (2004) Vegetation associated with the latest lying snowbanks in Australia. Honours thesis, School of Environmental and Applied Sciences, Griffith University, Gold Coast.	1. Subalpine zone 2. Natural tall alpine herbfield burnt in 2003 bushfires and adjacent unburnt tall alpine herbfield.
Scherrer P (2003a) Ch 4 Long term vegetation transects in the Kosciuszko alpine zone. In: Monitoring vegetation change in the Kosciuszko Alpine Zone, Australia. PhD thesis, School of Environmental and Applied Sciences Griffith University, Gold Coast.	1. Alpine zone 2. Natural short alpine herbfield and tall alpine herbfield
Scherrer P, Wimbush D and Wright G (2004) The assessment of pre and post 2003 wildfire data collected from subalpine transects in Kosciuszko National Park. Report for the Department of Environment and Conservation, National Parks and Wildlife Division.	1. Alpine zone 2. Natural tall alpine herbfield
Growcock A (2005) Trampling impacts in Kosciuszko National Park, Australia. PhD thesis, School of Environmental and Applied Sciences, Griffith University, Gold Coast.	1. Subalpine zone 2. Natural subalpine grassland and heath
Scherrer P and Pickering CM (2005) Recovery of alpine vegetation from grazing and drought: Data from long term photoquadrats in Kosciuszko National Park, Australia. <i>Arctic, Antarctic and Alpine Research</i> <b>37</b> , 574-584.	1. Alpine and subalpine zone 2. Natural tall alpine herbfield and subalpine grassland
	1. Alpine zone 2. Natural tall alpine herbfield

Table 1 cont'd

Data source	Floristic zone, vegetation type and disturbance type
Scherrer P and Pickering CM (2006) Recovery of alpine herbfield on a closed walking track in the Kosciuszko Alpine Zone, Australia. <i>Arctic, Antarctic and Alpine Research</i> <b>38</b> , 239-248. <sup>1</sup>	1. Alpine zone 2. Disturbed tall alpine herbfield on rehabilitated walking track 15 years ago and adjacent natural tall alpine herbfield.
Johnston F (2005) Ch 5 In: Exotic plants in the Australian Alps including a case study of the ecology of <i>Achillea millefolium</i> in Kosciuszko National Park. PhD thesis, School of Environmental and Applied Sciences Griffith University, Gold Coast. <sup>1</sup>	1. Subalpine zone 2. Disturbed road verge vegetation and nearby natural subalpine grass land.
Bear Z and Pickering CM. Impacts of fire on road verge vegetation and adjacent natural areas (unpublished data). <sup>1</sup>	1. Subalpine zone 2. Disturbed road verge vegetation and adjacent natural grassland.
Johnston F and Johnston SW (2004) Impacts of road disturbance on soil properties & on exotic plant occurrence in subalpine areas of the Australian Alps. <i>Arctic, Antarctic &amp; Alpine Research</i> <b>36</b> , 201-207. <sup>1</sup>	1. Subalpine zone 2. Disturbed road verge vegetation and adjacent natural subalpine grassland vegetation.

<sup>1</sup> Survey examined effect of anthropogenic disturbance on vegetation, therefore more likely to record exotic species.

**Table 2.** Number of sites where *Achillea millefolium* was recorded by location type in the Snowy Mountains. (Sources: *A. millefolium* specific surveys and experiments and 18 general vegetation surveys.

Location type	# sites	Sites with <i>A. millefolium</i> (%)
Infrastructure	44	11.7
Main road	104	27.6
Secondary road	115	30.5
Management trail	55	14.6
Walking track	26	6.9
Native vegetation	32	8.5
<b>Total</b>	<b>376</b>	<b>100</b>

snow in these sites was high, ranging from 1201 to 2500 mm of precipitation per year (Figs. 2 and 3). Most *A. millefolium* sites were in sites that had clear evidence of human disturbance (91.5%) particularly along the verges of roads and management trails in the subalpine and montane zones and at landfill sites at lower altitudes in the tableland zone (Fig. 1; Table 2).

The highest altitude site at which *A. millefolium* was recorded was 2100 m on Mount Twynam, 7 km from the highest mountain in continental Australia (Mt Kosciuszko 2228 m) where it was growing in the eroded wheel tracks of an old management trail (Fig. 4).

**Human disturbance**

The distribution of *Achillea millefolium* was strongly associated with anthropogenic disturbance, particularly roads and

infrastructure (Table 2, Fig. 1). The Snowy Mountains is dissected by roads, tracks and clearings producing an extensive network of edges. It was estimated that there are 1212 km of public access roads, 1238 km of management trails and 192 km of walking tracks (source: New South Wales National Parks and Wildlife Service GIS database).

Of the 376 sites at which *A. millefolium* was recorded 91% were in areas affected by human disturbance. This exotic was recorded along more than 100 km of walking tracks, public access roads and management trails in the Snowy Mountains – 104 sites along main roads, 115 sites on secondary roads, 55 on management trails, 26 on walking tracks and 44 around other types of infrastructure (ski resorts, rangers' stations, sewage works and power stations, Fig. 1). *Achillea millefolium* was recorded in only 32 sites where vegetation was classified as natural.

There are two major sealed access routes to the southern section of the Snowy Mountains, the Kosciuszko Road between Jindabyne and Charlotte Pass and the Alpine Way from near Jindabyne to Khancoban (Fig. 1). Along the Kosciuszko Road *A. millefolium* plants were found from the boundary of the montane/sub-alpine zone (Sawpit Creek) to Charlotte Pass in the high subalpine zone. In some areas along this road plants were also



Fig. 4. *Achillea millefolium* flourishing at high altitude in the eroded wheel tracks of an old management trail on Mt Twynam (2010 m). Rhizomes are encroaching into adjacent natural vegetation burnt in the 2003 bushfires (Photos: S Johnston January 2005).

found in adjacent native vegetation. Along the Alpine Way populations were found from the entrance to the Park (tableland zone) through to Thredbo Village and onto Pilot Lookout (Fig. 1).

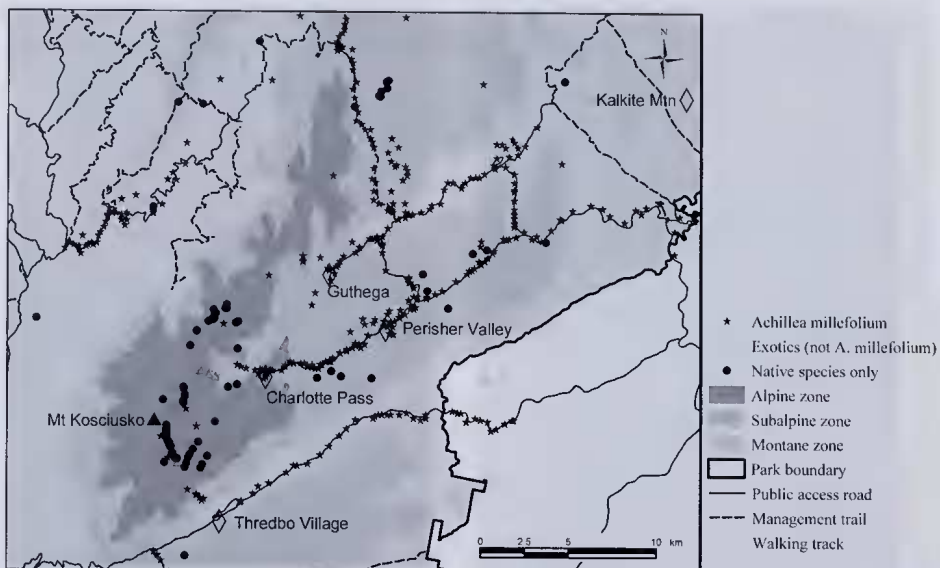
*Achillea millefolium* populations were also common along verges of minor sealed and unsealed roads, including the Guthega Road between the Guthega Power Station and Schlunks Pass road. Populations of *A. millefolium* were found growing along Schlunks Pass road through to Disappointment Spur with large monoculture populations found at the Disappointment Spur aqueduct. Populations were found along the following minor roads and management trails: the Cascade Trail, Pilot Lookout Trail, Farm Creek, Snow Ridge Road, Goat Ridge Road, Link Road, King Cross Road, Ridge Four Wheel Drive Trail, Valentine Fire Trail, minor roads within the Island Bend Road complex, Swampy Plain Bridge Road, and Rock Creek trail (Fig. 1). *Achillea millefolium* was also along management trails through the Jagungal Wilderness area.

Although currently uncommon in the alpine zone, there are isolated plants and small populations along the Summit Road,

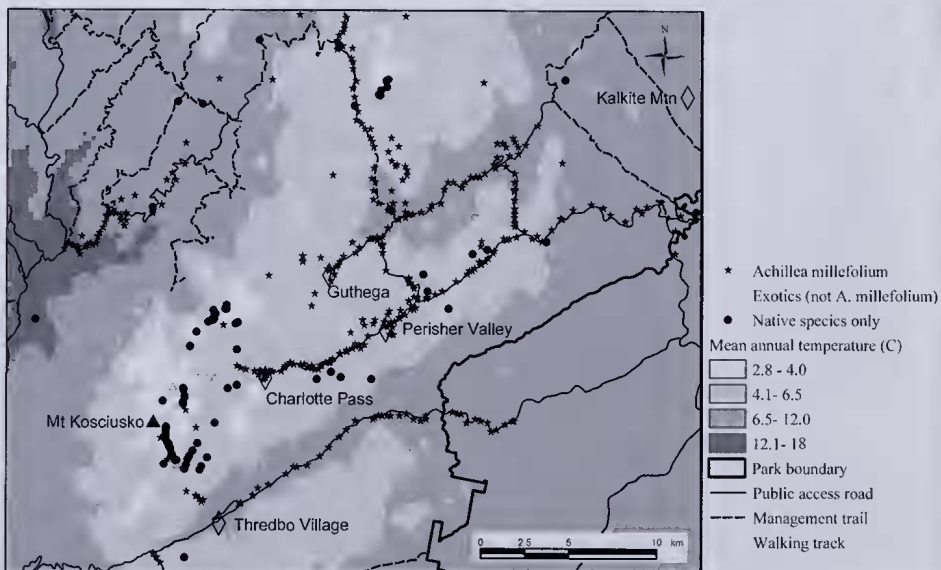
the Blue Lake walking track, the Main Range walking track and around Seaman's Hut near Mount Kosciuszko (Sanecki *et al.* 2003). Of particular concern is a population on a disused track on Twynam Ridge (2100 m, Fig. 4) which has increased substantially since the 2003 bushfires. In 1999 *A. millefolium* covered an area of ~20-40 m<sup>2</sup> on the track: January 2005 the area covered by *A. millefolium* was around 160 m<sup>2</sup> although this was discontinuous cover (Fig. 4). It appears to be spreading into adjacent sub-alpine grassland vegetation burnt in the 2003 fires (Johnston pers. obs.).

Other disturbed areas with *A. millefolium* include those surrounding infrastructure, such as the ski resorts, rangers' stations, sewage works and power stations (Fig. 5). Locations with large populations of *A. millefolium* included Perisher Valley, Smiggin Holes, Guthega Village, Cabramurra, Selwyn, Thredbo, Kiandra, Old Kiandra Goldfields, Island Bend, Guthega, Perisher, Wilson's Valley, Sawpit Creek, Falls Creek and Charlotte Pass. In some of these areas, dense monocultures of *A. millefolium* were recorded. For example, *A. millefolium* was seen

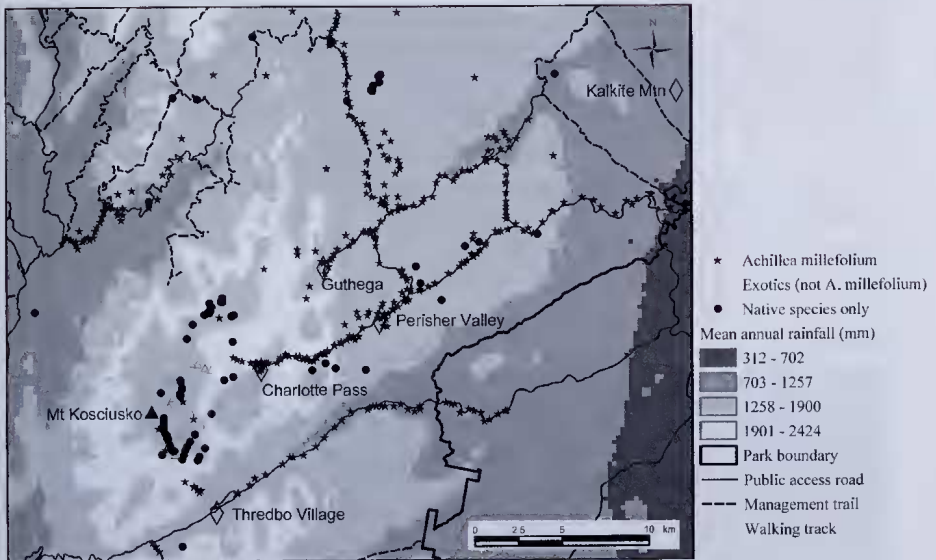




**Fig. 1.** Distribution of *Achillea millefolium* in relation to altitude/ floristic zone in the Snowy Mountains based on 376 sites with *A. millefolium*. Sites that were surveyed but did not contain *A. millefolium* but either other exotics or only natives also were included to show the extent of sampling.



**Fig. 2.** Distribution of *Achillea millefolium* in relation to mean annual temperature (°C) in the Snowy Mountains. Sites not containing *A. millefolium* but containing other exotics or only natives are included to indicate the total distribution of sites.



**Fig. 3.** Distribution of *Achillea millefolium* in relation to mean annual rainfall (mm) in the Snowy Mountains. Sites that were surveyed but did not contain *A. millefolium* but contained either other exotics or only natives also were included to show the extent of sampling.

growing up to 39 m from the road verge (Johnston pers. obs.) in outwash areas from a culvert opposite a ski lodge and ski lift in Perisher Valley.

#### ***Achillea millefolium* in natural vegetation**

Although most common in disturbed areas, *A. millefolium* grows in a number of natural vegetation communities including short alpine herbfield, tall alpine herbfield, sod tussock grassland, subalpine woodland and tall heath associations (as defined in Costin 1954 and Costin *et al.* 2000, Fig. 6) (Johnston pers. obs.). For example *A. millefolium* plants were observed in sub-alpine grassland (*Poa* spp.) near Dicky Cooper Creek, where there were no obvious signs of recent disturbance (Johnston pers. obs.). Along sections of the Geehi River *A. millefolium* was observed growing from the edge of the road down to the water edge (Johnston pers. obs.).

#### **Frequency and density of *Achillea millefolium* in the Snowy Mountains**

Although it is clear that there are many places in the Snowy Mountains where *A. millefolium* can be found there are also many disturbed and natural areas where it does not occur. Based on the general vegetation survey data, *A. millefolium* occurred

in only 12% of all sites where exotics were recorded. In natural areas *A. millefolium* was even less common and was found in just 4% of sites with exotics (Bear *et al.* in press) (Table 3).

The cover/abundance of *A. millefolium* was estimated at 300 sites along primary roads, secondary roads, management trails and other infrastructure. Cover/abundance was highly variable and appeared to be associated with the degree of disturbance, including if sites were likely to receive runoff from the road/trail (Table 4, Johnston and Johnston 2004). At some road drainage sites, *A. millefolium* was observed spreading into surrounding natural vegetation (Fig. 6). At sites adjacent to infrastructure *A. millefolium* was always recorded at either medium high or very high cover/abundance. Along main roads cover/abundance was more variable as it was recorded at low values as well as medium high values. Along secondary roads and fire/management trails cover/abundance was quite high and less variable. Along secondary roads cover/abundance was recorded as between medium to medium high and along fire trails it was medium high. In contrast, where *A. millefolium* was recorded along



**Table 3.** Number of sites recorded in 18 general vegetation surveys in the Snowy Mountains between 1986 and 2004. Number of sites with *Achillea millefolium*, number of sites with other exotics, and number of sites where no exotics were recorded (i.e. natives only).

Zone	Vegetation	# sites with <i>A. millefolium</i>	# sites with other exotics	# natives only sites	Total # sites
Alpine	Disturbed	1	48	17	66
	Natural	0	72	98	170
Subalpine	Disturbed	26	58	0	84
	Natural	10	53	15	78
Montane	Disturbed	5	55	1	61
	Natural	2	33	5	40
<b>Total</b>		<b>44</b>	<b>319</b>	<b>136</b>	<b>499</b>



**Fig. 5.** *Achillea millefolium* growing in front of the Marritz Hotel in Perisher Valley Snowy Mountains (Photo: S Johnston 1999).

walking tracks, the cover/abundance was low (Table 3).

### Discussion

*Achillea millefolium* is found from the tableland to the alpine zones of the Snowy Mountains with the majority of sites in the subalpine (57%) and montane (27%) zones. Nearly all sites with *A. millefolium* were areas where vegetation and soils have been affected by human disturbance (91%). Although the majority of *A. millefolium* sites were along main and secondary roads, the greatest density of *A. millefolium* was recorded around buildings.

Where *A. millefolium* was found on walking track verges, it was at low density, probably reflecting the lower intensity of disturbance in these areas.

*Achillea millefolium* was not common in undisturbed vegetation and occurred in less than 4% of sites where other exotics were recorded in the general vegetation surveys (Bear *et al.* in press). Therefore *A. millefolium* appears to be principally a weed of sites around infrastructure, including in areas with high water and sediment wash and nutrient-rich soils (Johnston and Johnston 2004). However it may be starting to establish in natural vegetation where

**Table 4.** Number of sites with different cover/abundance of *A. millefolium* at selected roads and other infrastructure in specific surveys in the Snowy Mountains between January and March 1999 and 2000. Low = isolated plants < 5 cm<sup>2</sup> in size. Medium Low = isolated plants > 5 cm<sup>2</sup> in size. Medium = discontinuous cover with distinct gaps between plants, area covered between 5 cm<sup>2</sup> and 30 cm<sup>2</sup>. Medium High = discontinuous cover with distinct gaps between plants, area covered between 30 cm<sup>2</sup> and 50 cm<sup>2</sup>. High = continuous cover, area covered between 50 cm<sup>2</sup> and 70 cm<sup>2</sup>. Very High = continuous cover, areas greater than 70 cm<sup>2</sup> in size.

Cover/ Abundance	Buildings etc # sites	Main road # sites	Secondary road # sites	Fire trail # sites	Walking track # sites	Total # sites
Low	2	20	1		15	38
Med/ Low	3	4	2	5	1	15
Medium	3	20	30	14	7	74
Med/High	14	24	68	36	1	143
High	3	4	6		2	15
Very High	11	2	3			16
<b>Total</b>	<b>36</b>	<b>74</b>	<b>110</b>	<b>55</b>	<b>26</b>	<b>301</b>



**Fig. 6.** Population of *Achillea millefolium* growing between eroded wheel tracks and in adjacent grassland vegetation in a subalpine area of the Snowy Mountains. The highest density appears at the lowest point of the road where greatest water and nutrient wash off occurs. *Achillea millefolium* also appears to be spreading out from the road into surrounding vegetation (Photo: Z Bear 2004).

it can be difficult to remove once established (Sanecki *et al.* 2003).

The distribution of plants is determined by both abiotic and biotic factors (Booth *et al.* 2003). The spread of a plant begins with the removal of dispersal barriers and/or the creation of suitable new habitats (Cousens and Mortimer 1995). From the distribution of *A. millefolium* in the Snowy Mountains, it appears that human activities have provided suitable habitat for its estab-

lishment and may have contributed to its spread. *A. millefolium* may not have reached the limits to its distribution in this area, as there are sites with characteristics similar to those where it has been found, which have not yet been colonised.

This species will continue to spread in the Snowy Mountains unless there is a successful control program. As the provision of infrastructure for tourism in the Snowy Mountains has created suitable habitat for

*A. millefolium*, there needs to be careful evaluation of alternatives to minimise its spread. This should involve limiting new infrastructure to already disturbed sites, selection of types of infrastructure that minimise disturbance (e.g. raised steel mesh walking tracks rather than gravel etc., Hill and Pickering 2006), and active ongoing rehabilitation of sites once they have been disturbed. This is particularly important under future climate change, which is predicted to increase the area of habitat suitable for *A. millefolium* in high altitude areas of the Snowy Mountains (Johnston 2005).

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## One Hundred Years Ago

### THE PLENTY RANGES IN EARLY SPRING.

by A.D. Hardy, F.L.S.

The Golden Wattle, *Acacia pycnantha*, seems to show a disposition to modify its foliage as the altitude of the habitat increases. The highland plants, which are generally more symmetrical and handsome, have mostly dull bluish coloured and often more pointed pyllodes as compared with the shining and dark green phylloded plants of the lowland. This blue-grey "bloom," such as is found on plums, grapes, &c., was also seen to be more pronounced on *A. dealbata* than on that species at a lower altitude, and the appropriateness of the common name, Silver Wattle, is readily appreciated.

The foliage of *A. pycnantha* here and on other parts of the Dividing Range is much eaten by insects. I remember that in September, 1905 on the Black Spur, I searched over twenty trees for a single small branchlet with entire phyllodes, but failed, to such an extent had these trees been attacked. Here in June *A. pycnantha* was in bloom, but the development of the buds is slow, for in the report of the excursion in January, 1900, Mr. Barnard states this species was then already in bud.

From *The Victorian Naturalist* XXIV, p. 133, December 1907.